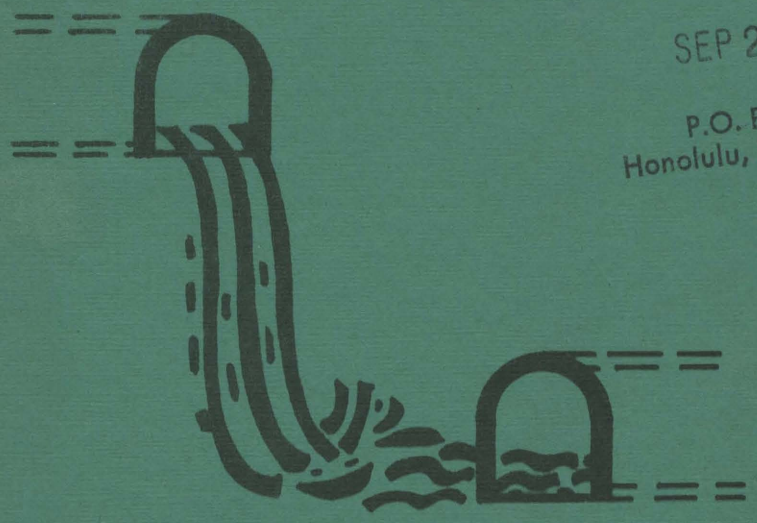
KOHALA
WATER RESOURCES MANAGEMENT AND DEVELOPMENT PLAN



PHASE I
PRELIMINARY FINDINGS AND CONCLUSIONS

MAY 1973
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Mr. Fred Erskine
Director
Department of Agriculture
State of Hawaii
Honolulu, Hawaii

Dear Mr. Erskine:

I am pleased to submit the Phase I portion of the Kohala Water Resources Management and Development Plan. Much of this study has been an evaluation and assembly of information, plans and ideas submitted by various land owners, water users and government agencies and I would like to thank them for their assistance in this phase of the plan.

Special thanks are extended to Chris Cobb, Al Stearns and Dale Sproat of the Kohala Corporation and to Bill Thompson of the State Department of Land and Natural Resources for their assistance and guidance in accomplishing Phase I of the Kohala Water Resources Management and Development Plan.

Sincerely,

Stephen P. Bowles

Stephen P. Bowles

SB:hb

KOHALA WATER RESOURCES MANAGEMENT AND DEVELOPMENT PLAN

Phase I - Preliminary Findings and Conclusions

BACKGROUND

For more than 70 years North Kohala has been an agricultural district where the economy has been devoted to ranching and sugar growing. The people of Kohala have adapted their life style into the total atmosphere of a sugar plantation operation and, to a lesser degree, ranching. On March 1, 1971, Castle & Cooke, Inc. announced the closing of the Kohala Sugar Co. By mid-June, 1971, the Governor had appointed a Task Force whose purpose was to study possible agricultural alternatives and to expedite an economic change from sugar to other agricultural products and to seek out diversification of the local economy. It became obvious to those involved that water was essential to the success of any economic transition and that, with the transition to diversified agricultural crops, it would be necessary to carefully scrutinize the water situation of North Kohala. A primary objective of the Task Force has been to secure jobs for those persons displaced by the loss of the sugar operation.

During the latter part of 1971, the Task Force created an executive committee composed of Lieutenant Governor George R. Ariyoshi, Hawaii County Mayor Shunichi Kimura and State Board of Agriculture Chairman Frederick C. Erskine. The purpose of the executive committee was to follow through on the details of projects initiated by the Task Force. The legislative session of 1972 produced Act 197 which pertains to the planning and development of North Kohala. In this Act, funds were provided for the planning and development of the area and

for feasibility studies for potential industries. Funds for the development of an irrigation water system were also allocated. The executive committee decided that, before monies were invested in an irrigation water system, it was important to determine what water problems existed within the district and also how the existing water facilities should be administered. At this juncture, it was decided that an appropriate step was to create what is being called the Kohala Water Resources Management and Development Plan. The objectives of this plan are:

1. To consolidate all water resources and facilities into a regional solution to develop, manage and distribute the water resources of North Kohala to the common good of agricultural, industrial and domestic water needs, both public and private.
2. Except for the initial Phases I, II and III of the Plan, to direct such management and development activities toward a self-supporting basis by revenue generated through water sales.
3. To enhance the economic strength of the North Kohala district and its people by the judicious use of its water resources.
4. To assist in the land use planning activities as related to the protection and the efficient use of the water resources.
5. To provide for local (North Kohala district) administration of the Kohala Water Resources Management and Development Plan in Phase IV.

The purpose of this preliminary report is to focus attention upon the most critical problems affecting the efficient development and management of the North Kohala water resources. The targets of Phase I have been to:

1. Inventory and identify the water resources of the Kohala Mountain with an emphasis on North Kohala.
2. Inventory and identify the water sources and primary transmission facilities.
3. Delineate water use areas by the domestic and agricultural needs, present and future.
4. Evaluate the proposed or present land use activities as related to the quality and quantity of ground water recharge.
5. To present recommendations for the pursuit of Phase II.

It should be emphasized here that the Kohala Water Plan is not a physical plan as such, but is an action plan. Because of the uncertainties in the outcome of the various proposed agricultural and other activities in the district, it is not appropriate at this time to have a detailed physical plan, but to have a plan which allows flexibility in the decision-making process. As the Phase I study progressed, it became evident that it was not necessary to place as much emphasis on the water resources as it was to emphasize the water sources, primary transmission and storage facilities now used. Once the sugar plantation shuts down its operation, two things may occur in relation to the water resources:

1. The water now being applied on the land will not be used.
2. Certain facilities might fall into disuse.

For these reasons, some of the emphasis in Phase I was shifted to first determining how much water would be used under the proposed agricultural pursuits and what should be done to insure that no assets, in the form of the physical facilities, would be lost to the economy. These changes in emphasis were

thoroughly discussed with Mr. Frederick Erskine of the executive committee and met with his approval. In looking toward a timetable for the Kohala Water Plan, it was felt that the inventory stage, Phase I, should cover a period of approximately four months which commenced on February 1, 1973 and is to be completed by the end of May. Phase II would begin on June 1, 1973. The actual time period would be defined prior to commencing the investigations. It was felt that the second phase would probably take a period of six months to complete. As stated earlier, Phase II would consist of the detailed investigations pertaining to the recommendations resulting from Phase I. Phase II can probably be completed by January 1, 1974. At that point, the Plan should immediately move into Phase III which would consist of the actual operation of a water utility, a complete maintenance operation of the facilities retained and the appropriate construction and other activities recommended by the priorities established in Phase II. Placing the Plan on revenue support in Phase IV will be difficult to accomplish; the timing cannot be accurately defined now pending the outcome of Phase III. It is probable that Phase IV can be in full operation within two to three years.

WATER RESOURCES

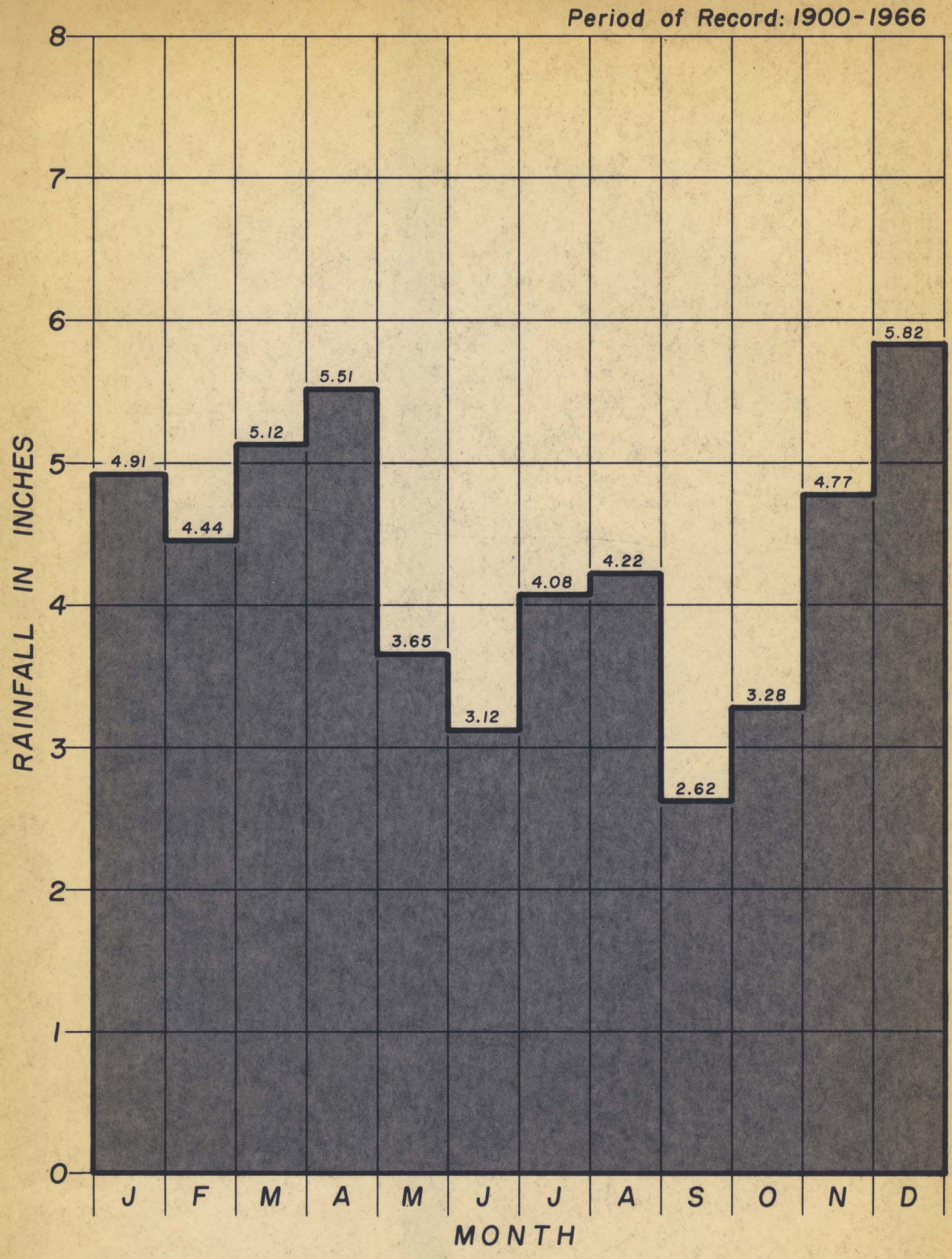
Numerous studies have been made of the water resources of the Kohala Mountain and, more specifically, of North Kohala. These studies deal with various aspects of the water resources and to varying degrees of detail. At the back of this report, in Appendix A, is a list of selected references reviewed during Phase I. No attempt will be made at this time to discuss the details of these studies. Such discussion is more appropriate in Phase II. When considering the availability of water resources, one of the most important items of discussion is

rainfall. This is particularly true when dealing with an agricultural economy. The necessity for applying water to the land is dictated by the rainfall patterns and rainfall volumes of the area.

In the past, the land use of North Kohala has been divided into two general categories - pasture land and sugar land. The historic events leading to the evolution of the sugar industry have been described in numerous reports but will be summarized here briefly. The sugar industry, at its very earliest stage, settled on lands which were readily watered by rainfall or by streams in the immediate vicinity of the fields. The Kohala Sugar Co. is no exception to this. It has, throughout its history, been faced with a number of water crisis situations.

Because of the lack of available streams within the immediate area of what are now the sugar lands, there was no real attempt in the early stage of sugar growing in Kohala to irrigate. Following the establishment of sugar as an agri-business in Kohala, it was recognized that irrigation and fluming water would be required for large-scale operation. Investigations were then conducted to determine the water development potential for the sugar activities. These investigations led to the development of the Kohala ditch, the Kehena ditch and groundwater within the plantation.

The dry land areas, from approximately Upolu Point to Mahukona, have never had sufficient amounts of water available to them. For this reason, with the exception of an early attempt at pineapple growing near Puakea, the lands have remained as dry land pasture used primarily during the winter months. Figure 1 is a graph showing the mean annual rainfall at U.S. Weather Bureau Station No. 1339 at Hawi. The seasonal variation of rainfall can be readily



MONTHLY MEAN RAINFALL

HAWI RAIN GAGE

USWB Station No. 1339

Figure 1

ascertained from this graph. When considering irrigation requirements, regardless of the crop, it is obvious that the year is broken into approximately two parts:

1. That period which stretches from November through May, which is considered for purposes of this report the winter months. That is, the period in which the heaviest rainfall occurs and which is dominated by cyclonic or Kona storms.
2. The second period runs from June through September and is considered the summer months. During this period, the rainfall is controlled by the orographic or trade wind patterns.

While the rainfall on the windward coast is normally steady and light, rain on the lee of the mountain is virtually non-existent. A weakening of the trade winds during the summer months will frequently cause periods of severe drought to the windward coast which is, in the case of Kohala, the origin of nearly all useable water resources. As was stated earlier, the sugar plantation was originally located in an area which normally had adequate rainfall for the growing of cane. However, during the drought periods, it was obvious that irrigation was required in order to provide stable crop production. The Kohala and Kehena ditches were built for this purpose. Both of these systems are largely dependent upon surface runoff. The surface runoff in Kohala occurs primarily on the windward slope of the mountain.

The Kehena ditch obtains its water from streams high up on the mountain and conveys the water to the Kohala ditch near Hawi. The Kohala ditch may be described for this report as having three independent portions, the first of which is commonly called the Awini section. This ditch section is located at approximately

the 1800-foot elevation beginning at Waikoloa stream near Waimanu valley and crosses the highlands lying between Waimanu and Honokane valleys via a tunnel. This tunnel intercepts various streams while enroute to Honokane. All of the streams in this section are fed by direct runoff.

During drought periods, the Awini section of the Kohala ditch either dries up or is at such a low flow as to be insignificant for the purposes of agriculture. The second segment of the ditch stretches from the Awini Falls and the intake at East Honokane Nui to where the ditch arrives in the plantation proper above Niulii. At East Honokane Nui, the waters from Honokane are diverted directly into the Kohala ditch at an elevation of approximately 1000 feet. As the ditch traverses between East Honokane and the plantation, it picks up what surface waters are available and conveys them to the weir above Niulii. During periods of drought, with the exception of the water picked up at East Honokane, no water enters the ditch. The waters obtained at East Honokane are groundwaters which feed the stream above the ditch. This flow is approximately 9 to 10 MGD (million gallons daily) during even the most severe periods of drought.

The third section of the Kohala ditch lies between the weir above Niulii and Puakea on the west edge of the plantation. As the ditch progresses across country it picks up several small streams which are fed either by direct runoff or from shallow tunnels, both of which go dry during periods of severe drought. As a result of this method of obtaining water for irrigation, when the weather is most severe and the greatest demand for irrigation water exists, the flow of the Kohala ditch will drop down to approximately 10 MGD. As mentioned earlier, the Kehena ditch drops its water into Kohala ditch in the vicinity of Hawi. The Kehena ditch

will go dry during drought periods, because it is fed also from direct surface runoff.

In the early 1900's, basal groundwater was developed near the coast. Because of the type of pumping equipment available at the time, that is, the large steam-driven pumps, the method of developing the water was to excavate a large vertical shaft to the water table. In the case of Kohala, such shafts are no more than 150 feet to the water table. At the water table, a large sump was excavated and a pump room was also constructed. The steam pumps were then placed into the pump room and the suction intake placed into the sump. Once the pumps were turned on, the sump would be de-watered and tunnels would be excavated at or slightly below sea level. Construction of these tunnels was then continued until there was an adequate amount of water to supply the steam pump. The Kohala Sugar Co. presently operates three such shafts. A fourth shaft has long been abandoned. As modern electric pumps became available they eventually replaced the steam pumps. Because of the type of construction used for the shafts and tunnel systems and their proximity to the coastline, these shafts produce brackish water, particularly during the late summer months when the pumping is heaviest.

During the 1960's it was felt that Kohala Sugar Co. had to expand its irrigation capacity and improve its methods of water application to remain a viable sugar producer. In order to do this, more reliable flow was required during the summer months. The Kohala Sugar Co. undertook a program to define where and what quality of water was available within the plantation proper, between Pololu valley and Upolu Point. Seven test holes were drilled for this purpose. As a result of these investigations, two producing wells were drilled to strengthen the

dry weather flows. Map 1 (at the back of this report) shows the location of all of the shafts, drilled wells and test holes. Water level contours are also shown on this map. Because of the problem of water source ownership, it was the decision of the Kohala Sugar Co. to place major efforts at groundwater development within the plantation proper and, furthermore, to place such facilities on land owned by Castle & Cooke, Inc. The ramifications of this decision will be discussed later in the report. All of these well and shaft developments produce water from the fresh basal lens.

Fresh water, being lighter, floats on the underlying salt water in a ratio of approximately 1 to 40. That is, for every 1 foot of fresh water above sea level, there are 40 feet below sea level. This is true for a steady state condition where the recharge equals the discharge in time. In Hawaii, it is common to have extremes in the amount of recharge as is evidenced by the rainfall. The high permeability of the lavas which constitute the aquifer permits tidal fluctuations to be transmitted into the aquifer. These two factors will modify the ratio to a certain degree.

In the case of Kohala, as shown by the water level contours in Map 1, large quantities of fresh groundwater are flowing through the basal lens to the ocean. It can be expected that the lens is very thick beneath much of the plantation proper and that large quantities of water are still available. The salinity of water produced from the lens depends largely upon the depth to which a well is drilled or constructed and also on the rate at which the individual well is pumped.

The drilled wells constructed in the 1960's produce fresh water at very high pumping rates. Based on the information provided by the existing groundwater

sources and from information provided by the studies in Appendix A, it would seem reasonable to expect that groundwater flow between Pololu valley and Upolu Point is on the order of 40 to 50 million gallons per day. When the plantation is pumping at its peak, approximately 20 MGD is pumped from the lens. It is also assumed that approximately 20 MGD can be developed in addition to the amount presently pumped by the plantation without seriously affecting the water quality of the area.

During the course of this preliminary investigation, it was obvious that future problems lie with the availability of power for the pumping of water. The power situation will be discussed in more detail later in the report. Because of this problem, it was felt that some investigation should be conducted in relation to potential source addition to the Kohala ditch. As stated earlier, this ditch supplies water to the plantation proper at an elevation of approximately 1000 feet, and the base flow of the ditch is fed by groundwaters from East Honokane. These groundwaters originate from dike compartments located within the Kohala Mountain. Leakage from the dike compartments feed Honokane, Waimanu and Waipio valleys and constitute the base flow of all three valleys.

In the 1940's, a tunnel was constructed at the head of East Honokane at an elevation of about 1900 feet. The purpose of this tunnel was to penetrate the dike compartments to supplement the low flow to the ditch. The results of this construction were only partially successful. Appendix B at the back of this report gives a more detailed evaluation and history of this tunnel.

There is no question that more water is available within the dike and fault systems beneath the Kohala Mountain. Perhaps a more important point is that

these systems can provide not only a greater low flow to the Kohala ditch but, if properly operated and managed, could be used as storage units to feed the ditch. This particular method of water development and management is used on the islands of Oahu and Lanai. The storage compartments contained within the dike or fault zones offer the opportunity to store great quantities of water in natural systems. It has been well documented that individual compartments between dikes or within a dike system may contain quantities of water in storage in amounts ranging from 1 million gallons to several billion gallons. These compartments offer a great deal of potential for the future of the water supply for the north end of the island of Hawaii.

Because of the nature of the land surface of North Kohala and the general shape of the valleys, there is very little possibility of constructing a reservoir similar, for example, to the Wilson reservoir at Wahiawa on Oahu which might be used to retain surface water available during the winter months for use during the dry summer months. The obvious solution to storage is to look to either the basal fresh water lens, which has a very large storage capability, or to the storage contained within the dike systems. It is not the purpose of this preliminary study to define which method of storage is the most appropriate for Kohala, but merely to point out the possibilities for a solution.

Emphasis, to this point, has been placed on the windward or wetter portions of Kohala. Because no wells have been drilled in recent years between Upolu Point and Kawaihae, little is known of the potential groundwater resources of the lee coastline. Based upon information obtained from wells drilled between Kawaihae and Keahole, it would be safe to assume that only brackish water can be

anticipated below an elevation of 1000 feet. Although there is high rainfall in the summit area of the Kohala Mountain, a major rift zone, oriented in a north to south direction stretching from Upolu Point over the top of the mountain to Waimea, would give indications that little of the rainfall on the summit can reach the basal lens on the leeward coast. This characteristic has been borne out on other islands of the Hawaiian chain. On the other hand, basal water produced from the brackish lens would be a valuable asset for mixing with domestic waters and also for irrigation uses.

In the future of the island of Hawaii, there will be a need for industrial uses of the groundwaters. Two cases have recently been presented to the Task Force which would require cooling water for industrial purposes along the coastline between Mahukona and Kawaihae. Both of these possible water users could use brackish water or might also be tied into a total conservation use of water from the Kohala ditch. Should the Kohala ditch be continued on past the present terminus at Puakea towards Kawaihae, it would be possible to drop water from the ditch for use as a coolant, providing these waters were either returned to the elevation from which they were dropped or put to a highly productive use for agricultural or domestic purposes.

WATER DEMAND POSSIBILITIES

For purposes of this report, the water demand for the North Kohala district has been reviewed in terms of all water needs - domestic, agricultural and industrial. At present there is no comprehensive agricultural water plan, although there have been plans prepared for the Kohala Sugar Co. in the past.

The domestic water plan, as presented by the Hawaii County Department of Water Supply in its publication dated December, 1971, is geared around the County General Plan. The County General Plan considers those areas zoned urban by the State Land Use Commission and the Planning Commission of the County. The intent of the Kohala Water Plan is to evaluate the long-term demands in addition to the short-term needs, both of the plans as outlined by the County and also those plans being developed for agricultural alternatives in the immediate future.

In the course of this investigation, many different ideas and plans for both agriculture and domestic activities have been reviewed. A number of these plans deal with problems and future plans not considered in either the water plan of the County or in the urban zoning of the General Plan. It is our position in pursuing the Kohala Water Plan that although existing plans should be weighed and considered carefully, the emphasis should lie in the potential for the long-range future. By using this approach, it will be possible to lay the ground work for future rezoning, population increases and industrial diversification, in addition to meeting the agricultural changes for the future.

The State has a major park planned at Lapakahi near Mahukona. In addition, the County Parks Department has a general recreational park planned to the north of Mahukona. The water needs as spelled out in the present County Water Plan are limited in scope to the urban zoning now shown in the County General Plan. This is not to say that the intent of the Kohala Water Plan is to undermine or alter the County General Plan or the water plans of the Department of Water Supply, but, rather, to view the land and its potential in relation to the available water resources. In so doing, it will facilitate future planning by the County and the

State with respect to water resources. Maps 2a and 2b are compilations of the present water systems, both agricultural and domestic, of North Kohala. Appendix C lists the major water assets of the Kohala Sugar Co.

In considering the domestic water demands of North Kohala, it is appropriate to separate the district into two general areas. The first lies between Pololu valley and Upolu Point; the second, from Upolu to the district boundary near Kawaihae. The majority of the water service within the plantation area is presently supplied by a number of small tunnel sources and conveyed to the user by a gravity system. In addition, the Kohala Sugar Co. also supplies water to this system from a well near the mill. The Kohala Sugar Co. furnishes domestic water by way of a gravity system to the village area of Niulii. With the exception of the well source, all of the tunnel sources must be treated and, on occasion, are very erratic, in both the quantity and quality of water available.

It would be desirable for all domestic water service to be met from wells penetrating the basal lens. This is feasible up to an elevation of 1000 feet or approximately the position of the Kohala ditch. Any future domestic water service above the ditch might be met by booster pumping or by restructuring the distribution systems above 1000 feet to make full use of the water tunnel sources. These tunnel sources could provide about .25 MGD of water for domestic or agricultural purposes above the elevation of 1000 feet. Because the County relies on public utility power to operate its pump systems, water cost for the domestic consumer is considerably higher than that for the agricultural user, unless the systems can be serviced by gravity.

There is no approved domestic water service to the Mahukona coastline at this time. A number of plans indicate that domestic water demands in the

foreseeable future might approach 4 million gallons per day if water is available to the area. In considering the possible means for serving this coastline, it is appropriate to look back to the fresh basal lens underlying the plantation area. Domestic water could be transmitted to the Mahukona coastline either by service mains along the existing highway to Mahukona or by a route along the existing Kohala ditch. In considering the long-range potential of the lee side of the island, it appears at this time that the desirable route would be via the upper elevation as water could be distributed to both agricultural users and the domestic system.

By making the sources available to both the agricultural users and the domestic service, there would be an overall efficiency in source development and operation. Perhaps more importantly, water service would be available at higher elevations with a more reliable flow, thus opening up new possibilities for both domestic needs and agricultural interests. As shown on Map 3, the potential demand is sufficiently greater for the lee of the Kohala Mountains. Undoubtedly, the future of the district lies on these dry slopes. Any plan considering water transportation development, operating efficiency and utility operation must view this as a distinct possibility. It would appear to be unrealistic to take any other approach.

For many people, domestic living is more pleasant in the dry, sunnier areas of the islands. In agriculture, it has been proven that the artificial crop control possible in the dry sections of the islands is the most desirable area to locate crops. In considering the future of the dry coastline, water use efficiency should always be foremost in the thinking of both the planners and the water user. For this reason, it should be the position of the various government agencies

approving waste disposal facilities that waters consumed for domestic uses which are concentrated into sewage treatment plants must be treated adequately for reapplication to the land. There will never be too much water available for the lee coastline of the Kohala Mountain. Water conservation by this means should be foremost in the thinking.

The domestic water systems presently operating in the district have come about by necessity. As the area was being populated in conjunction with the growth of the sugar industry there were numerous, diverse camps. The water systems built to serve these individual camps were constructed according to the separation of services. The systems themselves are numerous and will not be reiterated here; however, they can be seen on Map 2a. As the County began to take over the service to domestic consumers, it was forced to inherit the basic systems in use at the time. Consequently, the water service is difficult to plan as it grows. It is recommended that serious consideration be given to a reorientation of the thinking involved in the planning of the domestic systems in the area.

The present service zones are established along an axis which runs from the high elevation to the low elevation. It is recommended that thought be given to establishing horizontal pressure zones or horizontal service zones. These systems could be interconnected at particular elevations along a horizontal transmission concept, rather than a vertical transmission concept. This approach would lead to a simpler integration of systems in the future and also provide a more efficient and lower cost water service. Consideration should also be given to serving customers, such as small ranches, hog farms and individual household units via a combined water system. This is particularly true in the wetter

portions of the district. It would be unnecessarily expensive to provide water service specifically for the watering of the various animals where low volumes are involved. On the other hand, the hog raiser or chicken grower should not be expected to pay the same rates that are charged to individuals.

A question should be raised as to whether revenue should be based on the cost of development and transmission or on the type of use to which the water is applied. One of the conflicts and the major reasons for the relatively high cost of domestic water in relation to agricultural waters is centered around the necessity for providing pipelines, storage and source facilities which are far in excess of demand. These systems are sized considerably larger than is necessitated by demand, primarily to meet the fire flow requirements of the Board of Fire Underwriters. In an agricultural area, it seems most inappropriate to design water systems to meet urban fire hazard requirements. As the density increases in the future, there will be a necessity to have larger systems. The present buyer or user must pay for something which will be required at some future date. This is a conflict which should be carefully considered when planning for domestic water service.

What is being suggested here is that, if the sizes must be increased to meet fire demands, consideration must be given to utilize the oversizing which is required. This can be done by conveying agricultural water during the interim period which may extend from 10 to 50 years. If this concept is integrated into the thinking, it is very possible that adequate water can be provided for both the fire flow requirements and the uses of agriculture in the future; in other words, using a single source storage and conveyance system with a separation of rate

structures, not along the lines as presently applied, but an entirely separate rate structure for agriculture water users as opposed to domestic water users. This suggestion is being made primarily for the area above the Kohala ditch from approximately 1000 feet on up the mountain.

One of the plans being considered for the upper elevations is an agricultural district in which a permanent home owner may live on a large parcel of land, such as 25 or 50 acres. One of the problems facing the County in meeting this type of service is that the water use is so small and the system so expensive that it has provided many roadblocks to this type of land utilization. Agriculture is the major concern of the Kohala Plan. As shown on Map 2b a large amount of land in Kohala is presently irrigated. An equally large amount of land between Upolu and Mahukona is suitable for irrigation. The major problems are the water availability for irrigation of these new lands and those related to land ownership. It is not the concern of this Plan to be involved in land ownership as such, but rather to concentrate its efforts on the potential of the land. One of the big questions faced in accomplishing or pursuing this Plan is what crops will be grown.

Phase II should contain a detailed analysis of the water demand for the individual crops to be grown particularly in relation to the acreage required for these crops and to the geographic location of the crops. In order to determine how much a particular crop might be able to pay for water, several rough analyses were made of the present cost of water supplied to the sugar lands, both for pumped water and for ditch water fed by gravity operation. A study was also made of the water cost problems in relation to the growing of grain. Appendix D gives a source by source cost of pumped water presently supplied to the sugar areas.

This data was furnished by the Kohala Sugar Co. and is based on their cost and accounting methods. The cost of the water delivered now is based on the cost of power charged to the pumps and the cost of the maintenance and delivery of gravity waters. In no case is water charged at more than $50/MG (million gallons). By contrast, domestic water retails at more than $350/MG. During the course of this preliminary investigation, it was determined that the present grain growing activities of the Kohala Grain Corporation was based on a water cost of $50 per million as charged by the Kohala Sugar Co. It appears that the $50 per million is a reasonable cost based on the present water production costs. On the other hand, this water charge is relatively high in relation to productive capability of the grain crops. This, then, presents a serious problem in initiating a major grain growing operation for Kohala. Discussions were held as to what the potential is for the grain crops and what the water demand might be under different sets of conditions. The present grain experimentation activities are very marginal. It appears that two major actions must occur in order to place these activities on a paying basis. First, a careful breeding program must be instituted to provide the grain varieties which are best adapted to the Kohala area, both for climatic conditions and production levels; second, the water operations, both in application and in ultimate growth, must be carefully evaluated in order that the cost of water delivered to the user can be in line with his productive capability and, therefore, his ability to pay.

The Kohala Corporation has indicated that they definitely plan to pursue the grain production. The acreage that might be set aside for grain is very uncertain at this time. It may range from 300 acres to more than 5,000 acres.

For water planning, this is a difficult situation to cope with. In addition to the grain activities, it was decided that the dry areas from Upolu to Mahukona should be reviewed in terms of the potential for agricultural demand. At this time, it is very difficult to provide any firm guidelines other than to state that the land is presently in dry land pasture and that, if water is available for this land, a large potential exists for agricultural production. Most probably, this agricultural production would be centered around irrigated pastures. How such pasture activities might be pursued is still subject to evaluation. The land at this location is excellent for this type of activity as well as many other agricultural uses. In order to realize the full potential of the North Kohala district, studies should be made to determine how these lands can best be utilized, regardless of their ownership.

With the exception of these two potential major water users, the grain production and the irrigated pasture, the only water users which have firm commitments at this time are several small operations which provide high revenue on limited acreage. The major ones at this time are the tropical foliage activities near Hawi and the possible orchid culture operation near Mahukona. Undoubtedly, more of these smaller activities will be planned for the district. It should be kept in mind that these farms are water users of a very limited nature and are capable of paying higher water costs than the bulk irrigation users.

It is the intent of this Plan, beginning with Phase II, to carefully define the water cost zones which may be anticipated for the agricultural users. Such an approach has not been used in the water activities of Hawaii. The sugar industry evolved its water production costs by trial and error. The Kohala Water Plan

will rely on empirical cost information obtained from agricultural activities throughout the State. The actual cost data will be fitted to the sources, the peculiar maintenance problems which are required for the future, and to the various agricultural pursuits of the district.

The discussion to this point has involved two types of agricultural water users; the bulk irrigation user and the high revenue, low volume water user. A third type of agricultural water user should be considered in the course of this Plan. This user would be one which applies the latest trickle irrigation methods on orchard-type activities. Such orchards might consist of guava production, papaya production, macadamia production and various other related activities. There are no definitive costs available in Kohala for the water which might be required by such crops. The Kohala Water Plan should consider where such crops might best be located and how water might be supplied to these crops at what cost.

North Hawaii has a definite water need for the future. It should be a consideration of the Kohala Water Plan to evaluate whether or not it is reasonable to expect exportation of the water resources from the North Kohala district. The Plan should be ordered to first, handle the agricultural water requirements of the district; second, to meet the potential domestic and industrial water needs of the district; and third, to consider the potential for exportation of water. There is without a doubt a future need for more water over the entire dry coast of the island of Hawaii. There has been no comprehensive planning with respect to these future water needs. While it is not within the scope of the Kohala Water Plan to consider these needs in detail, it is within the scope of the Plan to define how

much water lies untapped within the North Kohala district and to determine how much water would be required for the district in the future. Any surplus might then be considered for future export.

CRITICAL PROBLEMS

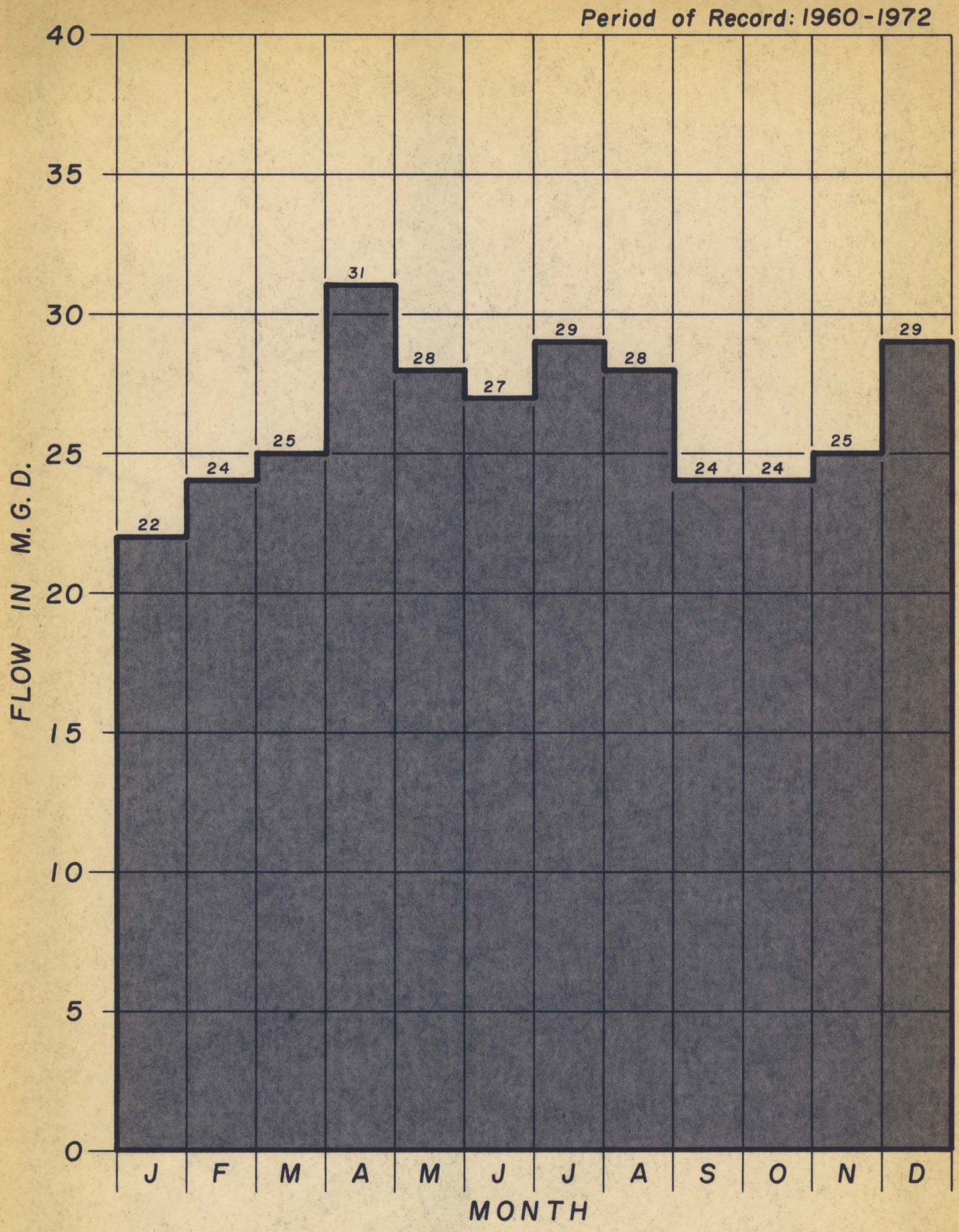
Because it has been stated in the formation of the Kohala Water Plan that a major objective of the Plan was to direct the water operations toward a self-supporting basis at some point in the future, it is necessary to outline the problems related to water costs. The pumped sources which presently supply the irrigation water can be separated into two categories; one, the shaft operations and two, the drilled well operations. The shafts have very high pumping rates and have relatively difficult and expensive maintenance problems. In Appendix D, the operating cost of both the drilled wells and the shaft operations have been summarized. Water is produced at a cost ranging from $20/MG to $90/MG, depending on the size of the installation and lift required.

The Kohala and Kehena ditches both supply gravity water to the agricultural pursuits. A preliminary review has been made of the operations of the Kohala Ditch Company and its problems. The Kohala Ditch Company has been trimming its maintenance program for a number of years. Some 20 to 30 years ago, there were about 25 persons employed by the company. The total personnel now working for the company is limited to five. This has serious ramifications on the maintenance of the system. In addition, the Kohala Ditch Company has been replacing the wood flumes throughout its entire system, but primarily within the plantation proper. These wood flumes have been converted to prestressed concrete flumes and are definitely a valuable asset for the future. Appendix E contains a detailed

history of the ditches and the status of the flumes. Through the years, the Kehena ditch has been gradually placed into a secondary role. This is most probably the future for the dtich as it is very unreliable and on occasion goes completely dry. On the other hand, it is extremely valuable during periods in which the Kohala ditch must be shut down for major maintenance activities. For this reason, the Kehena ditch can never be abandoned.

Figure 2 shows the water supplied over a 13-year period by the Kohala ditch. This flow is made up of the base flow of 10 MGD from East Honokane Nui and the intermittent surface flows from Awini and elsewhere along the ditch. When considering the operation of the Kohala ditch for the future, there is a very difficult problem which must be anticipated. As long as the Kohala ditch has been supplying water to meet the needs of the company which owns the ditch, it has been possible for the agricultural company receiving the water to gamble on the rainfall during the summer months. Basically, this means that the sugar company has been able to plant fields with the idea that water will be available when it is needed. In some respects, this is one of the major problems leading up to the failure of the sugar operations. Because the peak need for water occurs at the time when the least water is available in the ditch, there are many periods in which the crops do not receive adequate water. As long as this gamble is kept within the company, it has a certain degree of control. In considering water distribution for the future, no organization can be expected to contract for the sale of water on the speculation that water may be available at the time it is needed. This, then, provides a major constraint for the Kohala Ditch Company operations.

The Kohala Ditch Company has been in a serious financial position for the last few years. The water it sells is considerably below the cost of pumped water,



MONTHLY AVERAGE FLOW

KOHALA DITCH

Figure 2

even the cheapest pumped water. On the average, the Kohala-Kehena waters are being sold at approximately $20 per million as opposed to the average $50 per million of pumped water. This obviously must receive careful attention and evaluation in Phase II of this Plan.

The cost situation becomes more complicated because the pumped sources now rely upon power generated by the plantation. When the plantation shuts down, the low-cost power will no longer be available unless action is taken to retain the generating facilities. Appendix F lists the generating assets of the plantation. Presently, the only possible alternatives to low-cost power other than the plantation power are (1) some sort of agreement with Hilo Electric Co. to provide power at a rate which permits pumped water to be supplied to agriculture at a reasonable cost; and (2) to provide independent power units for pumping. These units might be supplied by diesel or propane fuel.

Phase II of this Plan should place a major emphasis on a solution to the power problem. Such a solution might be to grow crops as a source of fuel for running the present power facilities. Falling back on the public utility as a source of power for agriculture is the least desirable approach.

It is recommended that a systematic evaluation be made of the cost of water for any crops which might be considered for the North Kohala district. Attention must be paid to this problem as it may be the difference between success or failure of the crop. Upon reviewing the organizations which might be considered to own and operate the water sources and systems for North Kohala, it was found that there is presently no operation which can realistically meet the needs of the district. The County Department of Water Supply is generally

mandated to supply domestic water for the County. It is not geared to supply agricultural water, although consideration should be given to some such activities by the County in the not too distant future. The State, under the Department of Land and Natural Resources, has operated agricultural water systems at Waimanalo, Oahu, Waimea, Hawaii, and on Molokai. In the case of the Waimanalo and Waimea systems, revenue does not meet operating cost. Although the State has, in the past, been able to assist in providing capital funding for projects of this nature, the position of the State in the future appears more difficult.

Reference is made here to Appendix F. This appendix contains an article from Science magazine, April 13, 1973, titled Water Commission: No More Free Rides for Water Users. This article says that the National Water Commission, which was created by President Johnson in 1968, has stated in its first draft that agricultural water for the future must pay its own way. With the three exceptions pointed out earlier, nearly all the agricultural water supplied in the state of Hawaii has been initiated or developed by private industry. Regardless of what laws may exist, it appears that the desirable approach for the future, both in terms of attitudes on the part of the Federal Government and the financial position of the State, would be for Kohala to direct its water development activities toward self-sustaining operation.

Serious consideration should be given to the formation of a water co-op which is constituted of the State, County and various large private landowners and water users within the district. The purpose of this suggestion is to open the door for possible approaches for the future. A number of interviews were conducted with both public and private individuals in the district and the general

feeling was that such a possibility should be explored in Phase II of this Plan.

The water rights involved in the North Kohala district consist of two types - (1) those rights to groundwater contained within the Kohala Mountain dike system and the basal lens (although there is no definitive right established to these waters, it has generally been accepted in the state of Hawaii that these waters belong to the overlying landowners); and (2) those surface water rights which traditionally go with the land under Hawaiian law. It is the feeling of this investigator that the water rights situation should not be emphasized in great detail in this Plan. The reason for this is that water rights in the history of Hawaii have presented a number of serious constraints to the efficient management and development of the water resources of the State. It is felt that a more positive approach of community cooperation should be initiated with this Plan. Water should not have a price tag on it. It should be considered essential to the life of the community, and therefore is priceless. The objective of this Plan is to provide water to sustain and enhance the community. Therefore, it is felt that maximum effort should be applied toward the objective of cooperation on the part of the landowners and water rights owners, including the state of Hawaii.

Land ownership in the district of North Kohala presents another problem in the pursuit of the Kohala Water Plan. In the past, the ownership has limited the capabilities of agri-business, particularly in the case of the Kohala Sugar Co. The complexity which exists between the water ownership and the land ownership has been one of the primary reasons for the demise of the Kohala Sugar Co. To explain this a little more, the water rights were divided among the state of Hawaii, the Bishop Estate and the Kohala Sugar Co. The plantation

distribution system, including the Kohala ditch, was owned and operated by the Kohala Sugar Co. Because the Kohala Sugar Co. did not own the primary or base flow source for the Kohala ditch, it was limited in its sphere of capital improvement. For the Kohala Sugar Co. to go into the windward side of the Kohala Mountain meant a great deal of capital investment which must be spent on the ownership of others. A second point, in relation to land ownership, is that some land parcels owned by the Kohala Sugar Co. were separated by the land ownership of others. This provided for a difficult situation in the development and transportation of water, as well as other operational problems for the plantation. Here again, consideration must be given to the community solution as opposed to either a government or private solution to any problems in the district of North Kohala.

SUMMARY OF RECOMMENDATIONS FOR PHASE II

In order to pursue the Kohala Water Plan in a systematic and rational manner, it is recommended that the Task Force organize a group of consultants, either private or public, which can deal with the specific and detailed problems in Phase II. The primary effort should be applied to:

1. A detailed evaluation of the power situation.
2. An evaluation of water rights with the objectives of the Plan in mind.
3. Defining how the land ownership-agricultural situation can best be overcome to provide for the efficient growing of crops and for the efficient development and transportation of water to the subject lands.
4. Evaluate and develop a suitable water organization to meet the overall objectives of the Task Force and the community.

5. Explore the most efficient method of developing water to meet both agricultural and domestic needs for the future.

6. Determine the water resources potential of the basal lens and the dike system within the mountain and also the most appropriate method of utilizing the surface runoff. In this connection, it is recommended that the Task Force immediately take action to retain the principal gauging stations along the Kohala ditch for the future management of the system. The State has presently determined that these gauges are no longer needed for the evaluation of the water rights within the ditch complex. It is recommended that the physical stations be retained and that it will not be necessary to operate any gauges at this time.

Because of the complexity of the Kohala Water Plan and the ultimate objectives of the Plan, it seems far more appropriate to undertake the pursuit of the Plan by means of independent consultants who are coordinated by a senior consultant than to farm out the individual problems to the various government and private agencies that presently exist. It will be very difficult to properly coordinate the activities to a common objective and still integrate the knowledge of various specialists.

In order to obtain the proper organizational structure for pursuing Phase II, it is recommended that Frederick Erskine, William Thompson of the Department of Land and Natural Resources and Stephen P. Bowles, consultant for Phase I, together organize the personnel involved for the sursuit for Phase II. Because of the preliminary nature of Phase I, it is difficult to define all of the problem

areas which may ultimately be faced during Phase II. For this reason a certain amount of flexibility must be retained in the organization. Continuity is essential to the success of the Kohala Water Plan, and Phase III must begin immediately after the completion of Phase II. The thrust of Phase III will be to assume the operations, maintenance and construction required for water service.

In summary, the preliminary investigation has focused attention on the major problems faced in pursuing the Kohala Water Plan. There are also a number of smaller problems which must be solved, and a group of consultants appears to be the best method of achieving success. The major problems faced in the next two to three years are those of resolving the power problem, organizing the proper water utility operation, getting a clearer definition of the various plans being developed for both agricultural and domestic uses and, perhaps most important of all, maintaining and operating the existing water facilities. Monies appropriated for water development are best applied towards restructuring the water resource situation in the North Kohala district and in providing the tools necessary for the economic growth for the future.

APPENDICES

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January 18, 1954

Mr. E. W. Broadbent, Manager
Kohala Ditch Company
Hawi, Hawaii

Dear Sir:

This letter is to report the results of my recent trip to Kohala. I expected to go with you into Honokane Nui Valley and carry out the geologic surveys discussed below, but was, as you know, prevented from doing so by the weather. The conclusions summarized here are, thus, the result of the study and discussion of data previously collected.

Bulkheading at Koeling Tunnel

The Koeling dike tunnel in Honokane Nui was completed in 1946. In 1948 a bulkhead was completed across one of the dikes to permit utilization of part of the dike storage. The valves were first closed in January 1949 and the operation of the bulkhead was tested a number of times in 1949 and 1950, but then not for a couple of years prior to 1953 when it was again tried once. The flow of the tunnel was recorded during the trials in 1949, but unfortunately there is no record of the tunnel flow immediately prior to the first closing. There is thus no way of estimating the increases in flow resulting from storage release. During the trial in 1953 there was no provision for measuring the flow of the tunnel, but the gain by release from storage was estimated from the flow of Honokane Nui as measured by subtracting from the ditch flow at the main weir after subtracting the flow of Awini water and Honokane pump water. This method provides a better measure of the overall effects than measuring the flow at the tunnel, because operation of the bulkhead storage change in the affected dike compartments certainly alters the flow of natural springs not measured in tunnel flow. It lacks precision, however, because of uncertainties in the calibration of the several measuring devices involved. It appears from the 1953 trial that the increase in ditch flow resulting from release of bulkhead stored water is on the order of 5 mgd, a day after opening, tapering off to 2½ or 3 mgd after 14 days, the reduction in gain decreasing with time as expectable. This quantity of water is worth a good deal during dry periods.

One limitation to the present storage is the height to which water can at present be stored. The 1949 trials indicated that the pressure, behind the closed bulkhead flattened out at 99 psi, equivalent to a head of about 230 ft. This probably represents the elevation of an overflow point. From the topography, the elevation of the outcrop of the bulkheaded dike above tunnel level was estimated at 200 feet. When the bulkhead was first recommended, the choice of dike for sealing was made in order to provide the

greatest width of dike compartments for storage. It was suggested, however, that dikes farther back in the tunnel would provide greater heights of storage and that a second bulkhead might be desirable to take advantage of the extra storage volume. If the estimate of the performance of the present bulkhead is correct, and if it is judged valuable in terms of the costs of the bulkhead alone, about $6500, serious consideration should be given to the construction of a second bulkhead for additional storage.

In order to evaluate well the present performance the following will be necessary:

1. Reconstruct and recalibrate the main weir. (This is a large job, but is worth doing on other grounds.)
2. Improve the Parshall flumes measuring "plantation water" ahead of the main weir.
3. Check rating of Awini weir.
4. Repair leak in bulkhead.
5. Operate bulkhead through a complete cycle in dry weather. Close and leave closed about a month, then open and leave open about a month, computing Honokane Nui flow as main weir flow less the flows of Awini water, Honokane pump water, and Plantation water.

In order to select a site for the second bulkhead the following will be necessary:

1. Current meter survey in tunnel to determine inflow points.
2. Study of altitude and structure of dikes in tunnel.

Pumping from dike wells in Honokane Nui

An additional way of developing dike storage in Honokane Nui has been suggested, pumping from a well or wells to be drilled in the dike compartments.

One site for such a well that is obviously going to be of interest is just above the main Honokane Nui intake. This site is about 100 feet higher in elevation than the lowest outcrop of a large dike, the next to the lowest dike mapped in the valley. The degree to which other dikes or other structures seal this compartment to the north is uncertain, and the water table in this compartment may be so low that pumping is uneconomical. It may be very desirable, therefore, to investigate other sites farther mauka and farther into the dike zone. The following will be necessary steps in evaluating the possibility of developing water from a well in the dike zone and selecting a suitable site:

1. Current meter study of stream gains in the valley.
2. Study of the position, altitude, thickness, and structure of the dikes outcropping in the valley.

3. Diamond drill hole above the main intake, and very likely at least one more diamond drill hole farther mauka.
4. Possibly a recharge or pumping test well, also to be drilled with the diamond drill rig.

Yours very truly,

EXPERIMENT STATION, HSPA

By

Doak C. Cox
Geologist

DCC:sp

cc: Kohala Sugar Co.
Castle & Cooke, Ltd.
O. H. Lyman
Library (2)

USEFUL INFORMATION - DECEMBER 31, 1971

PUMP DATA:

Electrical Pumps:

6 Pumps - Capacity 25.5 M.G. Day
5 Booster - Capacity 13.5 M.G. Day

Pump Pipe Lines and Syphons:

Hoea and Booster	24" Pipe	5,900 Feet	
Waikane	16" "	3,000 "	
Low Lift Kohala	13¼" "	343 "	(Abandoned)
Kohala Old Stable to Mill	13¼" "	775 "	
Halelua Concrete Reservoir to Kohala Old Stable	24" "	1,600 "	
Mill to Mill Reservoir	21" "	650 "	
Kohala Pump to Mill	24" "	1,775 "	
Kohala Mill to Ainakea (Across Waianai Gulch)	20", 24" "	1,733 "	(Abandoned)
Akamoa Gulch	24" "	650 "	(Abandoned)
Kumakua Gulch	24" "	608 "	
Waikaulapala Gulch (Union Mill No. 1)	12-3/4" "	1,500 "	
Mill Cistern to Cooling Pond	20" "	800 "	
Total		19,334 Feet	

Permanent Flume Lines:

Trash Flumes at Mill	.25 Mile
R.W. Box Irrigation Flumes	.06 "
Concrete Flume to Halelua Cistern	.22 "
Total	.53 Mile

O.H. IRRIGATION PIPE LINES:

Hawi-Alaalae #1	12-3/4" & 10-3/4"	9,080 Feet
Honomakau-Union	12-3/4" & 10-3/4"	12,601 "
Upolu #1	20", 12-3/4" & 10-3/4"	11,685 "
Ainakea-Union	14", 12-3/4" & 10-3/4"	16,460 "
Hawi-Alaalae #2	14", 12-3/4" & 10-3/4"	15,020 "
Upolu #2	24" & 12-3/4"	11,707 "
Upolu #3	16" & 12-3/4"	6,216 "
Upolu #4	14", 12-3/4" & 8-5/8"	7,549 "
Total		90,318 Feet

RESERVOIRS, WELLS AND TUNNELS:

Reservoirs:

Number - Total	19
Total Capacity of Reservoirs	224 Million Gallons

Wells: (Connected to Pumps)

	Shaft	Sump	Tunnel
Hoea	46 Ft.	15 Ft.	1,612 Ft.
Waikane	25 "	17 "	690 "
Kohala	115 "	20 "	673 "
Halaula	500 "	-	-
Union Mill #1	412 "	-	-
Union Mill #2	470 "	-	-

Tunnels:

Name	Elevation	Length	Supplies
* Lindsey	2,250 Ft.	300 Ft.	Kaauhuhu Homesteads etc.
McGill (3)	2,100 "	1,000 "	Twin Reservoir (Abandoned)
Halawa	1,000 "	380 "	Macadamia Orchard
* Watt 1	1,750 "	1,230 "	Hawi Village
Watt 2	1,700 "	1,658 "	Kohala Ditch (Abandoned)
Olding	1,600 "	930 "	" - (")
Cow Pen	1,700 "	1,000 "	Kohala Ditch (")
* Hapahapai	1,350 "	1,076 "	Hawi Village
Koelling	1,600 "	255 "	Kohala Ditch - Honokane
Puu Mimi	1,200 "	300 "	Kohala Ditch - Niulii 24
Bond Relief	1,000 "	1,038 "	Kohala Mill & Halaula Subdivision
Pae	720 "	25 "	Pololu Warehouse
Murphy	1,250 "	300 "	Niulii Village
Waipunalau	1,575 "	200 "	Kohala Ditch
Maulua	750 "	150 "	Makapala Village
Union	900 "	180 "	Union Camp (Abandoned)
Bond 2	1,450 "	700 "	Iole (Abandoned)

* Subdivision water systems to be transferred to County at a later date.

USEFUL INFORMATION - DECEMBER 31, 1971

IRRIGATION:

Ditches:

Concrete Lined:

Union	1.52 Miles

Main Supply Earth Ditches

Hawi	12.60 Miles
Union	1.10 "
Kohala	5.78 "
Total	19.48 Miles

Surface Irrigation:

Area	1,242 Acres

Overhead Gravity Irrigation:

Area	3,164 Acres (Net)

STORM DITCHES:

Soil Conservation & Diversion Ditches	123,989 Feet

DOMESTIC WATER MAIN PIPE LINES:

Niulii - 2" and 2½" Galv. Pipe (Murphy Tunnel)	14,000 Feet	
Makapala - 3", 2", 1½" and 1¼" Galv. Pipe (Maulua Tunnel)	13,300 "	
Halawa - 2½" Galv. Pipe (Halawa Water Head) (Agricultural Use)	9,000 "	(Abandoned)
Kohala - 10", 5" and 4" C.I. Pipe (2 Mill Lines from Steel Tanks)	7,000 "	
Kohala - 3" C.I. Pipe (Skilled Camp from Steel Tanks)	2,000 "	(Abandoned)
Union - 3", 2½" and 2" Galv. Pipe (Union Tunnel)	13,000 "	(")
Bond - 8" and 6" C.I. Pipe (Bond Relief to Steel Tanks)	8,800 "	
Bond - 6" Transite Pipe (Not in Use)	1,850 "	
Hawi - 1¼" Hawi Village to Herbicide Plant	3,500 "	
Hoea - 3" Galv. Pipe (Kahei to Cistern At Reservoir7)	5,700 "	
Total	78,150 Feet	

SEWER SYSTEMS:

	4"	6"	8"	
Hawi Village	2,275 Ft.	4,035 Ft.	280 Ft.	(Mainly Abandoned)
Halaula Village	7,400 "	3,205 "	4,080 "	(" ")
Niulii Camp	-	-	450 "	(Abandoned)
Total	9,675 Ft.	7,240 Ft.	4,810 Ft.	

KOHALA CORPORATION

ANALYSIS OF PUMPING COSTS
FOR THE YEAR ENDED JANUARY 31, 1972

Page 33
Schedule 1/1

	CLASSIFICATION OF EXPENSES							Million Gallons Water Pumped						
	Direct Labor				Service Charges									
Pumps	Hours	Amount	Materials	Sundries	Electric Current	Shops	Total	Irrigation	Mill	Domestic	Total	Cost Per M.G.	Lift In Feet Including Suction	Cost Lifting 1 M.G. 1 Foot
ELECTRIC:														
Kohala	73	$197.38	$3,028.40	$.	$ 21,592.81	$ 7,298.19	$ 32,116.78	.	1,350.432	.	1,350.432	$23.7826	275	$.0865
Hoea	112.1	301.55	1,205.27	1.68	18,881.25	6,601.96	26,991.71	698.333	.	.	698.333	38.6516	145	.2666
Waikane	7	17.85	161.67	3.36	8,971.70	3,464.48	12,619.06	339.751	.	.	339.751	37.1421	220	.1688
Halelua	.	.	5.32	.	13,966.79	769.67	14,741.78	.	.	190.584	190.584	77.3506	438	.1766
Union #1	.	.	106.65	.	21,656.78	1,855.97	23,619.40	293.570	.	.	293.570	80.4558	965	.0834
Union #2	.	.	265.28	.	29,308.19	1,844.32	31,417.79	331.425	.	.	331.425	94.7961	965	.2257
TOTAL	192.1	$516.78	$4,772.59	$5.04	$114,377.52	$21,834.59	$141,506.52	1,663.079	1,350.432	190.584	3,204.095	$44.1642	329	.1342

Appendix D Page 1 of 2

Basis 2.45¢/KWHr.

	Power Cost/MG	Est. Useful Life	Average Est. Annual Maintenance Cost For Est. Life
Kohala	$ 26.07	10 Yrs.	$ 9,000.00 (Incl. elev. etc.)
Hoea (Low)	36.19	10 "	4,000.00
(Hi) (Ditch end)	47.05	10 "	1,000.00 (+ 4,000 above)
Waikane	18.29	3 "	3,000.00
Halelua	86.26	10 "	850.00
Union #1 (965 Hd.)	85.18	16 "	1,500.00
Union #2	84.20	16 "	1,500.00
Union #2 (450 Elev.)	46.68		1,500.00 (Alt. to above)

NOTE: The maintenance figure is for pump and well piping only to pump discharge.

3/16/73

For "K.S. Co Files"
Author not stated

KOHALA DITCH COMPANY, LIMITED

General history, engineering features, maintenance and discharge data

The Kohala Ditch Company, Limited, was organized in the year 1904 for the purpose of the development and furnishing of water for domestic and agricultural purposes in the district of Kohala, Island of Hawaii.

The Company acquires its right to the water which was developed from two sources, first under a license from the Territory of Hawaii under date of March 12, 1904, to one J. S. Low, for a period of 50 years to enter upon, confine, conserve, collect, impound and divert all the running natural surface water on that portion of the Island of Hawaii called generally the "Kohala-Hamakua Watershed", which license was duly assigned to the Kohala Ditch Company, Limited and second, certain leases from the trustees of the B. P. Bishop Estate, covering all the waters of the Ahupuaa of Honokane dated November 19, 1904, for a term of 49½ years.

The project was promoted by Messrs. J. T. McCrosson, John T. Parker and John Hind, and the Company was incorporated on September 9, 1904, with a capital of $500,000.00 of which only 46% was paid in or $230,000.00. In addition first mortgage, six per cent, thirty year gold bonds were issued to the par value of $500,000.00 and sold to net the Company $456,000.00.

In 1914, a 30 per cent assessment on stockholders was levied to raise the sum of $150,000.00 to pay off indebtedness incurred by the Company in the purchase of the capital stock of the Kehena Water Company Limited.

The Kohala Ditch was located and constructed under the supervision of M. M. O'Shaughnessy, a civil and hydraulic engineer of national reputation, with Mr. Jorgen Jorgensen as resident civil and hydraulic engineer.

Construction was commenced in January 1905 and completed as far as Hawi by June 11, 1906, when the formal opening took place and delivery of water commenced, the remainder of the ditch, that is, to the present end at Puakea was completed towards the end of the following year.

The construction of the Kehena Ditch was started in 1912 and completed in 1914, under the supervision of P. W. P. Bluett, the then superintendent.

In 1918 and 1919, two centrifugal pumps, together with tunnels, ditches, intakes and pipelines were constructed in Honokane-nui, to pick up additional water below the main ditch under the supervision of F. C. Koelling, superintendent and civil engineer.

In 1932-33, 1125 feet of contour development tunnels near the site of the Honokane Pumps were constructed on three separate ash beds, from which springs were issuing, the attempt increased the flow by about one half million gallons daily.

Between 1934 and 1939, 6552 feet of the Awini Ditch was concrete lined, to conserve water being lost along the Honokane-nui gulch and so as to provide a more regular source of power for the pumps.

Between 1941 and 1947 a development tunnel, at the head of Honokane-nui gulch at an elevation of 1900 feet was driven. This tunnel 1862 feet long, pierced 23 dykes, (hard rock formations, from a few inches in width to 10 feet in thickness, being vertical intrusions in the general lava mass); and the present (1948) discharge is 4,000,000 gallons of water daily. This tunnel is to be closed about 500 feet in from the portal, by a bulkhead with control valves, so that the area between dykes can be made to act as a storage reservoir.

In 1921 the K. D. Co., Ltd. was declared a Public Utility and on January 1, 1924, it purchased from Kohala Sugar Company all of the plantation electric distribution lines and commenced the sale and distribution of electric energy in the North Kohala District.

The system as constructed and now operated, consists of three separate divisions, namely the Awini section, beginning at elevation 1927 feet, in the Wailoa stream and ending at the measuring weir (elevation 1881 feet) above the falls in Honokane-nui, 9 miles in length. This system is practically all underground in tunnels of about 5 feet by 6 feet in section, and has a maximum capacity of 30 million gallons daily, but has stopped flowing at the falls after a prolonged draught of about 3 months duration.

The Kohala section is 13½ miles long, beginning at elevation 1035 feet in the Honokane-nui and ending at elevation 935 feet at Puakea, the westerly boundary of the Hawi section. The maximum capacity of this section was constructed for a daily discharge of 75 million gallons, but to date the maximum daily delivery utilized has been 50 million gallons and the minimum flow 10½ million gallons daily from Honokane-nui. The tunnels are of horseshoe section 6 feet by 8 feet, the redwood box flumes are 5 feet by 7 feet and the open concrete lined ditches 4 feet by 10 feet.

The Kehena section 14 miles long, depends primarily on surface runoff for its water supply, starting at elevation 4195 feet in the Gov't Land of Kawaihae mauka and crossing the lands of Kahua Ranch and Parker Ranch. Delivering its water into two reservoirs, the Kehena Reservoir, 20,000,000 gallons capacity at elevation 2500 feet and Puuokumau Reservoir 150,000,000 gallons capacity at elevation 1880 feet. The tunnels are 4 feet by 6 feet in section, the ditches vary in size with the gradient and the maximum capacity is 50,000,000 gallons daily. From the outlet of Puuokumau reservoir, the ditch delivering water to the plantation, has a capacity of 7½ million gallons, and the average delivery is 3 million gallons daily.

Seven rainfall stations are maintained, together with the one on the Summit of the Kohala Mountains at elevation 5505 feet, these have demonstrated that the maximum percipitation is between the 3500 and 4000 foot contours, this over a period of 43 years, has shown the average percipitation at this elevation to be about 200 inches per year.

Watershed and Runoff

	Area Square Miles		Runoff Max.	Runoff Min.	M. G. Average Delivery
Waimanu	2.00	Future Extension	-	½	1½
Laupahoehoe	3.50	" "	-	½	2½
Awini	9.00	" "	30	1½	8
Honokane	4.50	" "		6½	
Honokane Pumps	.	" "		2	16
Honokane Tunnel	.	" "	45	4	
Plantation	11.00	" "		-	5
Kehena	3.00	" "	50	-	3
"	2.00	" "	50	-	2
Present Totals					
Kohala System	24.50	-	45	12	29
Kehena System	3.00	-	50	-	3

After Niulii and Union Plantation were united and later on in 1937, after all the plantations in the district were taken over by Kohala Sugar Company, the streams between Pololu and Kapaau, together with other available plantation waters were put into the Kohala system, when not required for other uses; 14 intakes and measuring weirs being operated for this purpose.

There are 22 intakes on the Awini - Kohala system and some 30 intakes on the Kehena system, with necessary control gates, dams, sluices and spillways.

On the entire system there are some 55 miles of mule trails and four miles of foot trails leading to the intakes; which are very picturesque and have attracted many visitors.

January 1, 1948

Physical Sub-divisions	Section Awini	Kohala	Kehena
Water Department			
Intakes	20	16	30
Stream Underpasses	4	1	1

Physical Sub-divisions	Awini	Section Kohala	Kehena	
Flumes	10 Armco	19 (17 Redwood 2 Armco)	2 R. W.	31
Tunnels	9 miles	7 miles	2 3/4 miles	18 3/4
Honokane Ash-bed Tunnels	-	2850 feet	-	
Honokane Dyke Tunnels	-	1991 feet	-	
Open Ditches	-	6 miles	5¼ miles	11 1/4
Drop Ditches (Streams)	-	-	6 miles	
Reservoirs	-	-	2 miles	
Centrifugal Pumps	-	2	-	
Mule Trails	25 miles	15 miles	15 miles	55
Foot Trails	2 miles	1 mile	½ mile	
Roads	-	-	2½ miles	
Bridges	4 wooden	8 wooden 12 masonry & concrete	4 ~~miles~~ 8 ~~miles~~	
Stone Lining	½ mile	6 miles	½ mile	
Concrete Wall	1½ miles	2 miles	-	
Concrete Arch	¼ mile	1 mile	-	
Plaster Lining	¼ mile	4 miles	½ mile	
Concrete Weirs	1	25	6	
Venture Meters	-	2	-	
Recorders	1	10	5	
Telephone Line	5½	24½	11¼	
Phones	4	15	4	
Dwellings	2	12	4	
Warehouses & Stables	2	8	3	
Pack Mules	2	14	2	
Employees	5	23	5	

Electrical Department

Primary Lines	32 miles with 883 poles.
Secondary Lines	13 miles with 450 poles.
Sub-stations	3
Transformers	92
meters	

With but one exception, the half mile long tunnel between Pololu and Honokane, where air drills were used, all of the work was done by hand drilling. Small wooden muck cars, running on 2" x 3" wooden rails, with strap iron tops, nailed to Kukui ties formed the main means of transportation in the tunnels.

A boat landing, with a hand operated derick was used at Honokane-iki, for materials and supplies required on the Awini Section.

This landing was served by small Inter-Island vessels and whale boats to shore.

A total of seventeen lives were lost during construction and up to date.

Several men fell off of the trails, while they were being built, a number through dynamite explosions; one fell into the pump chamber and broke his neck another was jammed between a boat (used in transporting materials from Niulii to Honokane, too heavy for mule packing) and the sides of the tunnel, from which injuries he later on died.

ACTUAL COSTS

Water Department

Awini - Kohala System		$ 694,231.19
Kehena System		153,454.72
Honokane Pump System		52,237.75
Ash Tunnels		7,952.34
Dyke Tunnels		66,411.64
Dwellings		13,706.27
		$ 987,993.91
Electrical Department		112,518.15
		$ 1,100,512.06

REVIEW OF CURRENT STATUS OF FLUMES IN THE KOHALA DITCH SYSTEMS - APRIL 1973

Flume No.	Location	Lenght Feet	Size	Material	Last Replaced	Condition	Next Scheduled Replacement (Est.)	Comments
			Awini Section					
1		42	72 in.	Armco	62/63	Good	82/83)	Will probably be replaced as
2		35	72 in.	Armco	65/66	Excellent	85/86)	needed with 12 & 18 in. D.
3		56	72 in.	Armco	65/66	Excellent	85/86)	aluminum pipes.
4		24	72 in.	Armco	65/66	Excellent	85/86	
5	Chiahuea	30	72 in.	Armco	66/67	Excellent	86/87	
6	Nakooka	58	84 in.	Armco	1969	Excellent	Life Undetermined	Replaced with aluminum pipe-18"
7	Kaukini	48	84 in.	Armco	64/65	Excellent	84/85	
8	Hono-Pue	36	84 in.	Armco	62/63	Good	82/83	
9	Honokea	54	4'x5'(Est)	Wood	64/65	Good	84/85	
10	Honokane Iki (East)	39	84 in.	Armco	1955	Fair	75/76	
			KOHALA SECTION					
1	Honokane Nui (West)	113	5'x7'	Wood	64/65	Good	89/90	Replaced with Pressure treated Pine.
2	Pololu	123	5'x7'	Wood	63/64	Good	88/89	" " " "
3	Waikama Gulch (East)	101	5'x7'	Redwood	1955	Fair	80/81)	
4	Waikama Gulch (East)	84	5'x7'	Redwood	1956	Fair	81/82)	
5	Miulii Gulch (By main weir)	102	5'x7'	Redwood	1955	Fair	80/81)	
6	Waikane Gulch	105	4'x7'	Concrete	64/65	Excellent	Life Undetermined	
7	Aamakao Gulch (East)	109	5'x7'	Concrete	1973	Excellent	Life Undetermined	
8	Aamakao Gilch (West)	82	4'x7'	Concrete	65/66	Excellent	Life Undetermined	
9	Puu Waiole Gulch	64	4'x7'	Concrete	65/66	Excellent	Life Undetermined	
10	Waiohia Gulch	92	5'x7'	Wood	63/64	Good	88/89	Pressure treated pine
11	Kaleva Gulch	183	5'x7'	Wood	1960	Good	85/86	Pressure treated pine
12	Palalua Gulch	119	5'x7'	Concrete	1973	Excellent	Life Undetermined	
13	Palalua Gulch	42	4'x7'	Concrete	64/65	Excellent	Life Undetermined	
14	Pali Akamoa Gulch (Iole 3)	58	4'x7'	Concrete	66/67	Excellent	Life Undetermined	
15	Kapaau Gulch	121	5'x7'	Wood	1960	Good	85/86	Pressure treated pine
16	Waikaulapala Gulch	136	5'x7'	Wood	1958	Good	83/84	Pressure treated pine
17	Hanaula Gulch	134	5'x7'	Redwood	1958	Good	83/84	
18	Hapua Gulch	90	4'x7'	Concrete	63/64	Excellent	Life Undetermined	
19	Aumakua Gulch	109	5'x7'	Wood	1959	Good	84/85	Pressure treated pine

SOCIAL AND RECREATIONAL FACILITIES:

HAWI:
1 Social Hall - Camp 17
1 Athletic Field - Union Mill

KOHALA:
1 Social & Meeting Hall

MILL AND FACTORY DATA:

Crusher - 3 Rolls 37" x 78"
1st Mill - 3 Rolls 37" x 78"
78" Gruendler Shredder
2nd and 4th Mills - 6 Rolls 35" x 60"
3rd Mill - 3 Rolls 35" x 60"
5th Mill - 3 Rolls 35" x 60"
Rated Capacity of Steam Generating Plant - 200,000#/Hr.
Tons Gross Cane Ground Per Hour: 1970 - 184.71 1971 - 186.1
Tons Sugar Manufactured Per Day: 1970 - 209.24 1971 - 269.24

POWER PLANT DATA:

Allis Chalmers Steam Turbine	9,375	K.V.A.
Westinghouse Steam Turbine - Kohala	1,250	"
G.E. Steam Turbine - Kohala	2,500	"
Hawi Hydro No. 1	437	"
Union Hydro	625	"
Total Capacity	14,187	K.V.A.
Total Power Generated in 1971	9,065,100	K.W.H.
Total Power Purchased in 1971	1,010,383	"
Total	10,075,483	K.W.H.
Total Power Sold in 1971	1,699,300	K.W.H.

* Hydro Pipe Lines:

Hawi	6,075	Feet
Union	7,900	"
Total	13,975	Feet

* Also used for Overhead Irrigation

Science April 13, 1973

Water Commission: No More Free Rides for Water Users

In the last threescore and ten years, at least 20 investigative bodies have been appointed to look into what should be done about the nation's water resources.

Now the National Water Commission, created by President Johnson in 1968, has come out with what some call the last water report. It is the last water report because henceforth water projects and the use of water resources will have to be integrated into comprehensive regional planning. Inland navigation will be part of national transportation policy, irrigation will be part of national agricultural policy, and so forth.

The draft report is very fat and contains hundreds of recommendations. There will be enough water to meet the country's needs for the foreseeable future provided that sensible pricing policies are adopted, says the report. Otherwise, it warns, certain areas, particularly in the Southwest, will be confronted by increasing shortages.

Its basic message is that the policy of using general tax revenue to pay for water resource development has served its purpose. ". . . [T]he West for which this policy was designed," says commission chairman Charles F. Luce, "has been won."

Related to this is the fact that almost all water in this country—agricultural, industrial, navigational, and municipal—is being supplied to users below its real cost. "Water is so important that the country can't afford in the future to give it away or make it available at less than cost," says the commission's executive director Theodore Schad. So, says the report, most government subsidies for water projects and waste treatment should sooner or later be eliminated, and ways should be devised to place the financial burdens as much as possible on the users of the water in question. Also recommended is universal installation of water meters. Many cities already have them but others, like New York City, encourage wastage by charging by the front foot.

The report says the way to promote realistic planning and efficient operation is to bring management as close as possible to operations. This would mean beefing up the capacities of states and localities, as well as the creation of a variety of types of regional compacts and commissions.

This enormous compendium of criticism and recommendations has come out of a commission whose creation was originally spurred by a regional political fight over interbasin transfers of water from the water-rich Northwest to the arid Southwest—specifically a proposal to augment the supply of the Colorado Basin through importing water from the Columbia River. Congress has since banned most studies by federal agencies for such projects.

Reduce Federal Role

The commission's basic philosophy runs counter to the trend of ever deeper federal involvement in the affairs of states and localities, and indeed is compatible in most respects with the thinking of the Nixon Administration. At least four of the commissioners are functional Republicans (one is a Democrat for Nixon) and chairman Luce, head of Consolidated Edison in New York and protégé of Senator Henry M. Jackson (D–Wash.), is a western Democrat. Luce and commissioner Ray K. Linsley, professor of engineering at Stanford University, are Johnson appointees. The other five commissioners were appointed by Nixon: Howell Appling, former Oregon secretary of state; Roger Ernst of Phoenix, a Department of Interior official under Eisenhower; Josiah Wheat of Houston, member of the Texas Water Quality Board; James Reed Ellis, a Seattle lawyer; and James E. Murphy, a Montana lawyer.

Despite the western orientation of commission members, the report has come as an unpleasant shock to westerners long-accustomed to being suckled at the federal breast. For the report says that the three major federal water resource development agencies—the Army Corps of Engineers, the Department of Interior's Bureau of Reclamation, and the Agriculture Department's Soil Conservation Service (SCS)—should call a halt to their free or near-free draining, damming, channelizing, irrigating, and canal building.

These agencies have performed nobly, but now their projects are becoming increasingly marginal, says the report, and they have created an artificial situation that makes it advantageous for states to accept federally subsidized developments even when real costs exceed the benefits.

Furthermore, water projects have been executed at cross-purposes with other federal policies. A major case in point is the fact that farmers are being paid to keep 50 million acres of cropland idle every year, while at the same time the government is paying up to 90 percent of the cost of reclaiming 9 million acres a year.

To cut down on unnecessary projects, the commission has recommended that all projects authorized more than 10 years ago be deauthorized, and that the government subsidize no new irrigation projects before the end of the century on the grounds that the nation has enough productive capacity to meet foreseeable demands through 2000. From now on, says the commission, beneficiaries of irrigation projects should be compelled to repay the costs in full, with interest. To westerners, this idea spells death to agriculture. Said one Idaho newspaper: "To recommend to Idaho that no more irrigation be developed until the year 2000 would be like telling Texas to cease drilling for oil and abandon all new developments."

Stream channelization is another practice that has long gone unquestioned. The SCS has so far straightened out 6,000 miles of streams and 12,000 more are authorized. From now on those who benefit directly should pay for these projects, recommends the report.

The users of inland waterways have not had to pay for their operation or maintenance, enabling them to keep their operating costs low and undercut railway competition. The commission says barge owners should be levied user fees which would be increased gradually until they cover all costs hitherto borne by the federal government. Barge owners have protested that the recommended charge, which would add 14 percent to their operating costs, would kill inland waterways. The commission does not agree.

Flood control is another kind of activity that has gained its own momentum. Dam building and diversion to

enable floodplains to be developed is a popular Corps activity that is paid for by federal taxpayers. However, as was proved dramatically in South Dakota and the Northeast last year, dams may reduce floods but they can't prevent them. Indeed, despite extensive dam building, annual damage from floods has gone up to $1 billion a year —this because buck-happy developers move into "safe" floodplains and then sell out, leaving valuable flood-prone commercial and residential developments. The commission recommends that there be increased regulation of floodplain development, and that hitherto nonexistent coordination between flood control and land-use planning begin.

The commission's rule of thumb on federal subsidies is that "subsidies are only justified if they serve some compelling social purpose." It says that the federal role should be to get out of the engineering and hardware end of water development and to concentrate instead on planning, licensing, and regulation. Federal activities should be limited to those that cannot be as efficiently performed by states, localities, or regional commissions.

The extent of future federal involvement in water projects may be related to the discount rate, which is also an item of contention. The discount rate is a vague tool used to compute the worthwhileness of a project by measuring future costs and benefits in present terms, with the dollar being used as unit of measurement. A high rate has the effect of discouraging large, long-term projects. The commission wants the rate raised to about 5.5 percent (present rates are as low as 3.5 percent). Environmentalists want the discount rate raised to 10 percent, the opportunity cost of private capital. Most important, they want a higher rate to be applied retroactively to projects authorized but not funded. This would force a reassessment of these projects and wipe many of them out.

For the most part, environmentalists find the report to be an encouraging attempt to curb heedless exploitation of resources and to integrate environmental considerations into all aspects of water planning. But they have some complaints—about the section on power plants, for example. The commission believes that much time can be saved if issues of power plant siting can be decided by a single certification proceeding, and recommends that licensing and permit requirements be consolidated, with a single agency to pass on the project and an independent board to balance the environmental and developmental values. Environmentalists argue there is no way to ensure that the board will give proper weight to environmental considerations. Worst of all, they say, the commission wants to put final resolution of any dispute in the hands of the relevant congressional committee, thus robbing the citizenry of recourse to judicial review (a recourse provided for in the National Environmental Policy Act).

One of the most controversial chapters in the report is that dealing with pollution. The commission chose to defy congressional intent as expressed in the 1972 amendments to the Water Pollution Control Act, which call for gradual reduction in discharges of pollutants, with 1985 as the target date for "zero discharge." The commission thinks this goal is ridiculous and that standards should be set so that "water is polluted when its quality has been altered . . . [so] that reasonable present and prospective uses as designated by public authorities are impaired." The report explains that less progress will be made under the present act than if more realistic standards are set. The cost of cleaning up that last 1 percent—in air, land, mineral, energy, and capital resources—will far exceed environmental benefits, it says.

Urban Sewage

Although antipollution forces abhor the commission's dismissal of the zero discharge goal, they are happier with the commission's ideas on federal grants to municipalities for the construction of waste treatment plants. In line with its cost-sharing approach, the report says the program should be phased out by 1982. However, in view of the "backlog caused by generations of neglect," the commissioners believe that the grant program should be stepped up to help all cities that need it. The cutoff date is intended as a spur to get the whole job done within the next decade.

From then on, they're on their own. "Municipal waste treatment, with its captive customers, is an ideal enterprise to put on a self-sustaining basis" through the use of sewer charges. The commissioners argue that this would not put an undue burden on the poor if the poor are "assisted by adequate income maintenance programs rather than by burdening the pollution abatement programs with welfare objectives."

The report dwells at length on the equities involved in multistate water transfers. ". . . [T]he topic of interbasin transfers generates passion. . . ," it says in one of its more colorful passages. It is recommended that present laws hindering these transactions be lifted and that the final decision be made by Congress in the interests of national economic development (a single state would not have the power to block such a project). Congress would also fix the amount of compensation to the area of origin. Environmentalists generally oppose interbasin transfers on ecological grounds and because transfers could stimulate growth in areas with inadequate carrying capacity.

The commission also struggles with the matter of water rights, an area which is exceedingly tangled and entrenched in tradition established even before the Constitution was written. Legal and institutional impediments should be lifted so that water resources can be put to their "highest and best use," says the commission. Indian water rights pose a special problem, and no solution has been recommended that is satisfactory to Indians who want to quantify and claim ancient water rights while denying reimbursement to long-time non-Indian users.

To facilitate future natural water policy development, the commission suggests the creation of a new high-level Office of Water Technology, and the consolidation of the National Oceanic and Atmospheric Administration with the U.S. Geological Survey in the Department of the Interior.

Further, Congress is advised to establish an independent board of review to evaluate proposed federal projects. It would be structured as an independent agency within the executive branch, chaired by the head of the Water Resources Council and manned by people appointed to set terms by the President.

The commission is expected to come out with its final report in a couple of months, after which the Senate Interior committee plans to hold hearings with commission members and the Water Resources Council. Public hearings will be held in the fall.

So far, it is difficult to gauge public or congressional reaction to the report, aside from a few specific issues that have been latched onto by environmentalists, irrigators, and Indians.

Industry as a whole is not complaining, since the commission's recommended definition of pollution would take a great deal of strain off their

antipollution budgets. But many business organizations concerned with water resources are appalled by what they see as a virtual stoppage of development if all projects must be self-supporting.

Furthermore, many observers have heavy reservations about returning so much authority for planning and execution of water projects to states and regions. They point out that many states have little competency in water matters, and the dangers of domination by special interests are great.

It will be some time before the thrust of future water legislation becomes clear. Right now, Congress is waiting to see what, if any, new legislative proposals are submitted by President Nixon along with the final report.—CONSTANCE HOLDEN

Map I

WATER RESOURCES & PRIMARY SOURCES
north kohala, hawaii

MAY 1973

Upolu Pt.

MAHUKONA

HAWI

KAWAIHAE

WAIMEA

KOHALA DITCH

KEHENA DITCH

NORTH KOHALA DISTRICT BDRY

SOUTH KOHALA DISTRICT BDRY

- DRILLED WELL
- SHAFT
- TEST HOLE
- TUNNEL
- 7' GROUND WATER ELEV. (Approx.) ABOVE SEA LEVEL
- DITCH SYSTEM

NORTH

4000 0 4000 8000 12,000

SCALE IN FEET

Map 2a

DOMESTIC WATER SYSTEMS
north kohala, hawaii

MAY 1973

COUNTY SYSTEM

KOHALA SUGAR CO. SYSTEM

Upolu Pt.

MAHUKONA

KAWAIHAE

WAIMEA

HAWI

NORTH KOHALA DISTRICT BDRY

SOUTH KOHALA DISTRICT BDRY

NORTH

4000 0 4000 8000 12,000

SCALE IN FEET

Map 2a

Map 2b

AGRICULTURAL WATER SYSTEMS
north kohala, hawaii

MAY 1973

Upolu Pt.

MAHUKONA

HAWI

KAWAIHAE

WAIMEA

KOHALA DITCH

KEHENA DITCH

PARKER RANCH SYSTEM

NORTH KOHALA DISTRICT BDRY

SOUTH KOHALA DISTRICT BDRY

NORTH KOHALA FOREST RESERVE

KOHALA MOUNTAINS RESERVE

- DRILLED WELL
- SHAFT
- BOOSTER PUMP
- HYDROELECTRIC PLANT
- PRINCIPAL DITCH
- RESERVOIR
- OVERHEAD IRRIGATION SYSTEM
- PIPELINE (non potable water to Mahukona)

NORTH

4000 0 4000 8000 12,000

SCALE IN FEET

Map 2b

Map 3

WATER DEMAND POSSIBILITIES
north kohala, hawaii

MAY 1973

(.25) DOMESTIC DEMAND, MGD

(1) AGRICULTURE DEMAND, MGD

GRAIN & FORAGE AREA

IRRIGATED PASTURE AREA

..... LOWER LIMIT OF ORCHARD & UNIRRIGATED PASTURE AREA

10"——— AVERAGE ANNUAL RAINFALL

— — — KOHALA DITCH EXTENSION

Upolu Pt.

30"

40"

50"

GRAIN & FORAGE AREA

(20)

HAWI

(.5)

LOWER LIMIT OF ORCHARD & UNIRRIGATED PASTURE AREA

(1)

(.25)

IRRIGATED PASTURE AREA

(25)

(2)

MAHUKONA

KOHALA DITCH

75"

100"

20"

(.25)

(5)

KEHENA DITCH

150"

DISTRICT BDRY

NORTH KOHALA

HAMAKUA

175"

(2)

10"

(25)

(5)

KOHALA DITCH EXTENSION

50"

40"

30"

20"

10"

NORTH KOHALA DISTRICT

SOUTH KOHALA DISTRICT

KAWAIHAE

WAIMEA

NORTH

4000 0 4000 8000 12,000

SCALE IN FEET

Map 3